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Spruce budworm

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UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

FOREST INSECT INVESTIGATIONS

PONDEROSA PINE A NEW HOST OF THE SPRUCE BUDWORM IN THE ROCKY MOUNTAIN REGION

By

J. A. Beal, Entomologist

and

F. R. Lewis, Field Aide

Forest Insect Laboratory,
Fort Collins, Colorado,
February 28, 1938.

U. S. GOVERNMENT PRINTING OFFICE 60918

116-2

Spruce budworm

COPY

335 Prospect Street
New Haven 11, Conn.

RLF
W.J.B
J.F.W.
JMW

Sept. 8, 1948

To: Mr. Bernard Brungard, Scientific Aid, Portland, Ore.
(Through R. L. Furniss)

From: C. F. Speers, Entomologist, New Haven, Conn.

Subject: Spruce budworm parasite collections.

Your last letter dated Aug. 29, was most encouraging. I'm certainly glad that you were able to make the last suggested pupal collection requested with individual isolations of each pupae. The recovery of Itoplectis sp. happens to be a very important point because Itoplectis conquisitor is very common in both east and west but Itoplectis obesus is not common in the east and has rarely been recovered here. They are very interested in securing a good source of obesus and hope that the recoveries made in Oregon are this species.

You mentioned that you were enclosing 75¢ for a Kodachrome. Evidently you forgot to enclose same for none was received. I am enclosing the Kodachrome and if you are still interested in having a print made you can have it done out there. Please return the original.

I am looking forward to receiving the remainder of the summers collections and to a possible different species of Tachinid. Yours for a pleasant and most enjoyable term at Oregon State.

/s C. F. Speers

Enclosures (1) One Kodachrome slide for Brungard.
(2) Box of extra duplicate Kodachrome slides for Furniss.

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UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE
WASHINGTON, D. C.
335 Prospect St., New Haven 11, Conn.

August 2, 1948

AIR MAIL

To: Bernard Brungard, c/o U. S. Forest Service, Heppner, Oregon

From: C. F. Speers, Entomologist

Subject: Spruce Budworm Parasites

I have just finished talking overthe parasite collections with Mr. Dowden and he is very pleased with our work. However, we overlooked one point which I was afraid of and this may still be rectified. We did not isolate each individual pupa. The adult *Itoplectis* (a hymenoptera similar in appearance to *Glypta*) emerges *directly from the budworm pupa* and, therefore, we may miss it under present plans. To remedy this it may still be possible to place all remaining budworm pupae from the pupal collections in the numbered mono-cylindrical containers which we already have set-up. Collect all adult diptera and hymenoptera from the vials and kill and place in pill boxes as planned.

If nearly all of the adults have emerged from the pupal collections (D) it would be highly desirable if you could make another pupal collection from Bottle Mountain and Tollgate. About two hundred unemerged pupae from each place would be fine and it could be a mixture from Douglas and white fir or from either one wherever collecting is easiest. Simply isolate each pupa in a gelatin capsule if these are available and take to Portland when you go. If gelatin capsules are not available place about 100 pupae in each mono-cylindrical container (without sawdust) and collect, kill and label just the hymenoptera. Insects other than hymenoptera which emerge from this collection may be discarded. Label this collection (G.). Best of luck.

CASpeers:eo

cc: R. L. Furniss ✓
P. B. Dowden

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spruce budworm

JMW
W.J.B
K.H.W.
J.F.W.

Forest Insect Laboratory
445 U. S. Court House
Portland 5, Oregon
August 3, 1948

To: Charles B. Eaton, Entomologist, Beltsville, Maryland

From: R. L. Furniss, Entomologist, Portland Laboratory

Subject: Spruce budworm airplane spraying project

Your memorandum of July 22 was received some days ago and the Heppner District maps were forwarded at that time. I hope they arrived in good shape.

I too was highly pleased to receive Beal's preliminary report on the high degree of kill obtained on the Kinzua project. It was evident on the area that the spraying was a success, but I was hardly prepared for the all-out kill actually obtained. In a way it is fortunate that Tommy Hall put a half dosage on one of the plots.

I suppose the Kinzua experiment will re-open the question of the effectiveness of the lower dosages. My own feeling is that with the one pound in one gallon treatment we have an effective and economically practical method that can be recommended in the West. Further experimentation is highly desirable but we need not hold off any longer on recommending control where needed.

One thing we should bear in mind is that on the Kinzua area, despite the mud and cold weather in the early stages, we had practically perfect weather conditions during the actual spraying. Both pilots did an exceptional job. And the budworm brood was probably as near the "right" stage as it would be possible to have it.

Whether all of these favorable circumstances could be duplicated on just any wide-scale practical operation is a question. We do know, however, that, when the spray goes on right and under favorable conditions, good kill will be obtained. That's the major battle.

In view of our experience with the Big Rock Flat airfield development project, I am pessimistic about developing airstrips for control project in the West. It's just too risky a business to stake success or failure on airstrips that may never dry out. My inclination is to use large aircraft from established fields. The helicopter also offers considerable promise, providing costs can be kept down.

This fall when the field work subsides we plan to do some additional experimental work with the Buckhorn line-throwing technique.

Within the next few days Buckhorn and Wear will begin on the resurvey of the Blue Mountain area to determine the status of the budworm infestation. All indications so far point to a bigger and better infestation with considerable kill developing. It remains problematical what, if anything, should be done in the way of control.

Brungard is still at Tupper following up on Speers' biological work. He reports that the parasites are coming out in goodly numbers. I believe that much good information will come from this phase of the work.

I hope that by the time you got home your wife was greatly improved. We were all very sorry that you had to leave so suddenly just as your efforts in organizing and conducting the experiment were bearing fruit. You can be sure that your work was greatly appreciated and I wish to thank you personally for making the project a success.

cc: FCCraighead
RCBrown

Note to Dr. Craighead:

We were pleased that Buckhorn's method of marking trees turned out so well on the Kinzua project. In fact we would have been in a bad way without it. There are refinements that need to be worked out, and we plan to work on them this fall. Also we will welcome suggestions.

RLF

116.2
Spruce budworm

Forest Insect Laboratory
445 U. S. Court House
Portland 5, Oregon
August 3, 1948

Mr. N. S. Rogers, State Forester
State Board of Forestry
Salem, Oregon

Dear Nels:

The checking of results on the budworm project on the Kinzua area was completed some time ago. Dr. James Beal, who was responsible for the checking of the budworm kill has sent us a preliminary report on the findings. A detailed report on all phases of the project will be prepared this fall. Meanwhile I know you will be interested in the "kill".

Beal reports in part as follows:

"Budworm mortality on all the sprayed plots is so uniformly high that comparisons between dosages or between plane and helicopter applications are not going to mean much.

"The airplane plots, sprayed at the rate of one pounds of DDT in one gallon of fuel oil per acre, all showed a larval mortality of 99 percent plus. The two pounds of DDT in two gallons of fuel oil could obviously be but little better. They too showed a mortality of 99 percent plus, and some were remarkably close to perfect.

"On the helicopter plots, where one pound of DDT in one gallon of fuel oil per acre was used, results were equally good with but two exceptions. On plot 10, sprayed in the evening instead of early morning as were all other plots, control appeared to be only about 96 percent effective. Plot 7 showed a mortality of 98 percent plus. All other similar dosages applied by helicopter gave a 99 percent plus mortality.

"On plot 12, where the helicopter applied ½ pound of DDT in ½ gallon of fuel oil per acre, mortality was low. Results were spotty and erratic and apparently 50 percent or less of the larvae were killed on this plot where, through an error, only one-half the intended spray was applied.

"On the check plots a heavy population of budworm larvae survived throughout the project. As far as we were able to determine, natural mortality during the summer larval stages appeared to be very low.

"The control on this project is astonishingly good, but since we were dealing with large populations there can be little doubt regarding the effectiveness of the spray applications.

> " Early morning airplane or helicopter applications of one pound of DDT in one gallon of fuel oil per acre will definitely give highly satisfactory control of the spruce budworm in the mixed fir-pine forest of eastern Oregon, if directed against the late larval stages.
>
> "The contrast between trees on the sprayed and unsprayed areas is already striking. On the sprayed plots, new growth, especially on the Douglas-fir, is greening up the trees again by covering the earlier feeding scars and red foliage. On unsprayed infested areas the bare twigs and reddish foliage of the firs are increasingly evident and they present a devastating scene. In some areas tree mortality is expected to be heavy this year."

In the light of this highly successful control experiment and because of the continued heavy infestation, it is highly desirable to make a complete resurvey of the situation as a basis for possible control action next season. To be most effective such a survey should be gotten under way at once, while the red foliage is still conspicuous.

This brings up the question of who should make the survey. Last season we made a generalized survey by aerial and ground methods. It was satisfactory for the purpose intended- to get a line on what was happening. Now something much more intensive is needed. Frankly the job has gotten too large for us to handle alone.

I would like to discuss this with you or one of your staff. I will be going through Salem on Thursday morning, August 5, and will drop in on the chance that you may be in.

In conclusion I wish to express my personal appreciation for the excellent cooperation by all of your men who were on the budworm project at Kinzua. The outstanding success was due in great part to the efforts of those men.

Sincerely yours,

R. L. Furniss
Entomologist

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WJB.

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH ADMINISTRATION
BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

Agricultural Research Center
Beltsville, Maryland
July 21, 1948

To: R. L. Furniss, 445 U. S. Court House, Portland 5, Oregon

From: F. C. Craighead, In Charge, Forest Insect Investigations

Subject: Marking plots

Eaton showed me the photographs of the ingenious device which Buckhorn developed for marking corners. This matter of marking plots and flight lines on larger areas is one that we must sooner or later give a great deal of attention. At the present time there just seems to be no method which will insure parallel flight lines and uniform coverage of a sprayed area. Each failure to get perfect coverage is a great handicap in any of our experimental work and of course of great importance in practical control. It would seem feasible to use this method of Buckhorn's not only with paint but with wind socks, aluminum tape and other things that might be pulled to the top of the trees. I would suggest that Buckhorn continue to think about it and let his originality have free range in perfecting it.

FC Craighead

cc: Brown
Yuill

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File No. 116.2 Spruce budworm
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UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH ADMINISTRATION
BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

Agricultural Research Center
Beltsville, Maryland
July 21, 1948

To: Brown and Furniss

From: F. C. Craighead, In Charge, Forest Insect Investigations

Subject: Spruce budworm results in Oregon

I just received copies of Beal's preliminary appraisal of the results of the spruce budworm applications in Oregon. This report is extremely encouraging. I am wondering if the variation in results here and in contrast to that in the Adirondacks last year may not be due to the greater pains taken in securing perfect coverage in the Oregon plots.

My thought in writing is to suggest that you and Furniss prepare a brief statement on the results of this work that can be given out as early as possible. With the apparent increase in the infestation in Maine this season and widespread outbreaks in the West a timely statement on control would be very helpful. I am suggesting that you and Furniss take the responsibility on this but any other authorship will, of course, be agreeable with me. Furniss might take the initiative in preparing a short note, not over a page or even less, and send it on to you for consideration, eventually getting it in here for clearance for publication in various outlets.

FCC

cc: Beal

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UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH ADMINISTRATION
BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

Agricultural Research Center
Beltsville, Maryland
June 24, 1948

AIRMAIL

To: R. L. Furniss, 445 U. S. Court House, Portland 5, Oregon

From: F. C. Craighead; In Charge, Forest Insect Investigations

Subject: Spruce Budworm Project

We are pleased to have your letter of June 21 noting the progress on the spruce budworm project. Looks like Buckhorn has some good ideas on markers. I hope his paint bombs prove practical. We have done an awful lot of discussing on this situation of markers and the Gypsy Moth unit has devoted a great deal of time to it. None of the ideas seem to be wholly practical. One difficulty with the marker that is placed on the foliage and covers only a small spot will be that it cannot be seen until the plane is almost on top of it. Of course, it might help some if the plane circled around and got its bearings before it came down on the strips. One of the ideas that has been discussed here is to apply some material in the spray itself that will show a deposit on the foliage. Another idea is for some sort of a marking device that will spot a group of trees every here and there along the line of flight. If you could drop your paint bombs every quarter mile it might make a good line of marks.

Recent observations by Hoffmann on the gypsy moth treated area in Pennsylvania that was treated with a C-47 demonstrated very forcibly the need for better marking and better control in flying so as to obtain more perfect coverage.

It is my private hunch that on much of our budworm work to date, the fault has not been with the poundage or gallonage but lack of effective coverage. Contrasting the helicopter and the fixed-wing plane on your job should develop some information on this point.

You have really had a lot of set backs and you deserve better breaks from now on. Eaton wrote us quite a little about his checking with Central Aircraft. It is gratifying to know that you have a heavy infestation to work with. That will at least remove one outstanding difficulty we had in our New York work.

cc: Mason

FC Craighead

116.2
spruce budworm

Forest Insect Laboratory
445 U. S. Court House
Portland 5, Oregon
June 21, 1948

AIR MAIL

To: Dr. F. C. Craighead, In Charge, Forest Insect Investigations

From: R. L. Furniss, Entomologist, Portland Laboratory

Subject: Spruce Budworm Project

This memorandum is written to advise you of the more recent developments on the budworm project.

All of the plots have been chosen, the corners marked, and the sampling points established. There has been considerable experimenting with different types of markers, both on the ground and in tree tops. At Buckhorn's suggestion, paint bombs were pulled up into tree tops by means of a line shot over the trees with a Lyle gun. The bombs containing about 3/4 of a quart of aluminum paint were detonated with dynamite caps. More recently 1/2 stick of dynamite has been added to improve the distribution. A whole stick was also tried but tended to defoliate the trees. In general the paint bombs are proving successful. Cloth markers of various types are also being tried.

Floods in the Northwest have affected practically everything including the shipment of spray materials for the budworm project. All materials are now on hand and ready for the project to begin on June 22.

Eaton checked in with the Central Aircraft people in Yakima where he calibrated their Travelaire 4000 which is to be used on the project. Their helicopter was not available for testing; so he plans to calibrate it on the project.

Speers reports that the buds should be sufficiently expanded and the budworm advanced to the proper stage by the June 22 deadline. The population is vigorous and abundant to date. Beal is beginning to wonder whether the budworms may not be a little numerous to count on the scale contemplated. At least we are favored with plenty of biological material.

The one thing that is giving us much concern is the airstrip. Recurrent cloudbursts of outstanding intensity have kept it and the country in general in a super-saturated condition, far too soft to put in flying shape. All that is needed is about one day of light blade work. Unfortunately it will be several days before anything can be done with it. We are planning to start operations with the helicopter by using the Kinzua road as a temporary airstrip. It will not do for airplanes; so we will have to get a break in the weather soon.

Except for Whiteside and the Forest Service survey crews, all our men are, or presently will be, on the budworm project. The State also has several men working on it; so, we are well manned after having gone through a period of shortage. The employment of Coulter, Wright, and Brungard beginning June 14 has helped out a great deal.

Brown arrived on the 17th and has been checking the work that has been done so far. He plans to stay here a week or ten days longer.

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BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE
~~WASHINGTON, D. C.~~

File No.
Noted by FPK
JMW
RLF
WJB

Forest Insect Laboratory,
Fort Collins, Colorado,
March 8, 1938.

Dr. F. C. Craighead,
Washington, D. C.

Dear Doctor Craighead:

I am inclosing for your information two copies of a report "Ponderosa Pine a New Host of the Spruce Budworm in the Rocky Mountain Region" which I have written up for the purpose of getting our meager notes on this apparently new biological strain of the budworm summarized and under one cover.

I am also sending copies to the other western stations as well as to the Regional Office of the Forest Service and the Supervisor of the Roosevelt National Forest.

Damage by this insect is more extensive than indicated in the report. An additional area of unknown size has recently been reported in the Gold Hill area of the Roosevelt National Forest. It is possibly an extension of the Sugarloaf infestation mentioned in the report.

We hope to conduct further studies on the budworm on pine this coming summer.

Very sincerely yours,

J. A. Beal
Entomologist
Forest Insect Investigations.

Incl.
cc-Miller
Keen
Evenden
Regional Office
Roosevelt Forest

PONDEROSA PINE A NEW HOST OF THE SPRUCE BUDWORM IN THE ROCKY MOUNTAIN REGION

By

J. A. Beal, Entomologist

and

F. R. Lewis, Field Aide.

Forest Insect Laboratory
Fort Collins, Colorado
February 28, 1938.

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PONDEROSA PINE A NEW HOST OF THE SPRUCE BUDWORM IN THE ROCKY MOUNTAIN REGION

INTRODUCTION

Early in 1937 the supervisor's office of the Roosevelt National Forest reported serious insect damage to the terminal and lateral shoots of ponderosa pine in the vicinity of Sugarloaf, Colorado.* A specimen of damage and one pupal case were submitted and tentatively identified as the spruce budworm. The area was examined on April 1 and a number of fragmentary pupal cases collected which were subsequently identified by Mr. Carl Heinrich as "presumably Cacoecia fumiferana Clems." Mid-summer collections of larvae, pupae, and adults were later forwarded to Mr. August Busck who positively identified them as Cacoecia fumiferana Clems. (one of many color varieties). Although yellow pine (ponderosa pine) has been listed as a host for the spruce budworm ** so far as is known no outbreaks have been previously recorded on this host alone but have been invariably associated with other host trees. The Sugarloaf outbreak is the first one where the spruce budworm (probably a biological strain of this insect) has been found exclusively in ponderosa pine.

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* Reported by Ralph Hill, Assistant Supervisor.

** Essig, E. O., "Insects of Western North America," p.739.

During the summer a careful watch was kept for this type of damage and additional infestations were noted in several distinct areas, some on the Roosevelt National Forest and others at considerable distance from it. From these findings it is evident that this insect is widespread and it may be present throughout most if not all of the ponderosa pine stands of the Rocky Mountain region.

In late summer some detailed observations were made of the spruce budworm on ponderosa pine in the Sugarloaf area and in another bad infestation near Hosa Lodge, Colorado. The data obtained are here written up for the purpose of having an office record of this apparently unknown biological strain. Mr. F. R. Lewis made many of the observations on the budworm on pine while stationed at Hosa Lodge CCC Camp in connection with biological studies on the Black Hills beetle.

Description

Since the spruce budworm has already been fully described * only some of the general characters will be given here.

The eggs are oval in shape and about 1 mm. in diameter. They are shiny with a light yellow-green tint. They are laid in rows with each egg overlapping the preceding one.

The newly hatched larvae are 2 mm. long and about 5 mm. wide with a very light yellow body and a dark brown head. As the larvae

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* Craighead, F. C., "Studies on the Spruce Budworm" Canadian Dept. of Agriculture Bulletin 37 - New Series Technical, Dec. 1924.

mature they change to a reddish brown with brown heads and are conspicuously marked with tubercles. The mature larvae are about 3/4 of an inch long.

The pupae are creamy yellow to brown or dark brown depending on their age. The abdomen has two transverse rows of spines on the dorsal side. There are a number of hooked spines on the posterior end.

In general color and appearance the moth (Fig. 1-b) is very different from any previously described (Fig. 1-a). It is smaller usually having a wingspread of less than 3/4 of an inch. The rear wings are of a silvery transparent appearance; the fore wings are mottled brownish or buff-colored. They are very different in appearance from the biological strain which attacks Douglas fir in this locality, being lighter in color and without the various shades of marking.

Life Cycle

Although the life cycle of the spruce budworm on ponderosa pine in the Rocky Mountain region has not yet been worked out in detail it seems advisable to give here the information we have obtained to date on this point.

Larvae. The budworm undoubtedly passes the winter as hibernating larvae within the silken hibernacula, although only one of these abandoned cases has been found and this one was on a shoot beneath the base of a needle sheath. Activity in the spring probably begins with the swelling of the buds in late May or early June when the young larvae feed on the pollen in the staminate flowers and the developing leaf buds. They mine the developing needles and feed on the bud surfaces and as they feed they spin a light web of silk about themselves. As the larvae develop they chew off many of the developing needles at the base. Most of the feeding is confined to the new growth. The majority of the larvae reach maturity by the end of the first week in July. The number of larval instars while not definitely known for this strain is probably six as with other strains.

Pupae. Pupae begin to appear the first week in July and by the first week of August nearly all have changed to adults. The average time for pupation was not accurately determined although with the few specimens observed it varied from one to two weeks. The pupae remain beneath the webs spun by the larvae on the infested shoots and are held in place by two large recurved hooks on the posterior end. No cocoon is spun for pupation.

Adults. The adult moths start emerging about mid-July and are fairly abundant until about mid-August. Copulation takes place shortly after emergence and eggs are deposited during the following 24 to 48 hours. Moths lived from 6 to 11 days in captivity.

Eggs. Eggs are laid between mid-July and mid-August during the flight period of the moths. They apperently hatch in from 9 to 10 days. The day before hatching they turn dark grey in color. When first deposited they are light yellow to pale green and a little lighter in color than the needle on which they are laid.

Nature of Injury

Injury to ponderosa pine by the spruce budworm can usually be detected by the presence of short brown needles on the current year's growth and by the absence of needles on the preceding year's growth on trees which have been infested for two years (Figs. 2-5). The injury is confined to the current year's growth of terminals and laterals alike except in particularly heavy infestations when the older needles are also eaten. The staminate flowers are also fed upon heavily but this type of injury is not particularly noticeable except that those fed on crumble more easily when touched. Feeding occurs principally at the base of the needles which are soon cut off and thus a comparatively greater amount of injury is caused than would be the case if the entire needle was devoured. The small larvae bore into the needle sheath and feed on the base of the developing needles, sometimes mining individual needles. As the larvae increase in size they continue eating the needles off at the base and hold them in position for a time by spinning a web about them. By the second year this web breaks apart so much that most of the dead needles are blown away by the wind and the twig is left bare. On most of the twigs examined the first year's feeding apparently did not kill them and they started to grow again the second year, as evidenced by the elongation of terminals and formation of new needles. Where the shoots coming out the next year were attacked they were not only killed by the budworm but the preceding year's growth was also killed. No dead trees have yet been observed in any of the infestations but it is doubtful that the trees will be able to withstand much additional injury. Only two years injury has thus far been found on any of the infested areas.

Habits

Some characteristic habits of the budworm were noted during the study and these, even though quite incomplete, are briefly mentioned here.

During the day most of the moths remain hidden in the foliage of the trees on the underside of the pine needles unless disturbed, such as by jarring the limbs, when they scatter in all directions and seek new hiding places. At dusk the moths fly only among the branches of the trees on which they had been hiding but as darkness comes on they fly from tree to tree. Those moths which were reared in the cages nearly all emerged at night and the eggs were all deposited at night. Eggs are laid the first day or two after the moths appear. Each female usually lays all her eggs (averaging about 40) in a single night but some require two nights to complete the work. Eggs may be deposited in a single mass or in several masses. One female which was under observation laid 46 eggs in 3 different masses on as many needles during a single night. A male and a female only 12 hours old were placed together in a vial. They mated within one hour and within the following 12 hours the female laid 30 eggs in 2 masses. The following night she deposited 10 more eggs on another needle. Eggs deposited on August 4 turned dark grey on August 11 and all hatched on August 13. The female begins egg laying at the tip of the needle and works toward the base depositing a few at a time, each egg overlapping the preceding one. The eggs are laid on the inside of the pine needle in long chain-like masses, usually on the old needles. Males and spent females are attracted to lights at night but gravid females were not thus attracted. Copulation will take place right after emergence although it appears that it generally takes place the second night after emergence. With the relatively small number of insects under observation no difference was noted in the sex-ratio. Males and females emerged in about equal numbers and lived from 6 to 11 days in captivity.

Each rain took a heavy toll of lives among the moths. Those which were washed to the ground were soon captured by the large black carpenter ants.

After the eggs hatch the young larvae crawl around on the needles where the eggs were deposited and some hang by long silken threads and are carried by the wind to other locations. On August 11 while searching for eggs among the foliage Lewis found over 50 newly hatched larvae clinging to his arm.

Although an occasional Douglas fir could be found growing in a group of heavily infested pine not a single case has yet been noted where the larvae of this biological strain of budworm has been found feeding on the fir. In the Redstone Canyon outbreak on the Roosevelt National Forest where the spruce budworm has killed considerable Douglas fir none of these insects has been found feeding on the ponderosa pine which is found in the stand.

Extent of Injury

Very little is known as yet about the extent of infestation by this insect on ponderosa pine in the Rocky Mountain region. The Sugarloaf infestation near Boulder, Colorado covers an area of about two sections in size. There is evidence of two years heavy feeding here on some spots although much of it was badly damaged in 1937 for the first time. Another large infestation about 1/4 mile wide by 5 miles long occurs near Hosa Lodge west of Golden, Colorado. Still another sizable infestation covering about one section was found northeast of Wah Keeney Park, only two or three miles from the Hosa Lodge infestation. Injury on these two areas appears to be about as far advanced as on the Sugarloaf area. Additional spot infestations were also found on the Roosevelt National Forest. One of these was found south of Gold Lake near Ward, Colorado and is estimated to be from 20 to 30 acres in extent. There is also evidence of light infestations southeast of Allenspark and in parts of Poudre Canyon. Some infestation was also observed about 40 miles north of Fort Collins near the Colorado-Wyoming line. It therefore appears that the budworm is widespread on this new host and it quite possibly occurs throughout much if not all of the ponderosa pine type in the region. Damage by the spruce budworm has already attracted considerable attention and if it increases at its present rate for another two or three years the damage done to ponderosa pine will undoubtedly be very serious.

Parasites

During the summer it was found that about 20 percent of the pupae were parasitized. By far the most common parasite emerging from budworm pupal cases was a species of *Itoplectis*. These parasites probably deposited their eggs in the larger larvae although this point was not definitely determined. Parasitized or dead pupae had stiff abdomens while those of living pupae were notably flexible. One other specimen of an *Ichneumonid* also emerged from a pupal case. Parasites emerged both at night and during the day.

Of the few egg masses collected in the field one was found to be heavily parasitized by an undetermined species of *Chalcid*. All reared parasites will be submitted for specific determinations.

Collections made after most of the larvae had already pupated and after emergence of moths had been heavy showed that about 45 out of a hundred pupae were dead from some unknown cause. Not much significance can be attached to this because dead pupae would naturally remain on the twigs long after the living ones had transformed to the moth stage.

Predators

The only predator observed at work on the budworm was the large black carpenter ant which captured many of the moths after heavy showers had beaten them down onto the ground.

Control

No attempt has been made to conduct any artificial control experiments against the spruce budworm on ponderosa pine; however, it is believed that if the need arises it can be satisfactorily controlled by the use of poison sprays such as are now used against the spruce budworm on Douglas fir in parts of the region. Under present forestry practices and with the insect in its present state where no timber is yet being killed, artificial control is probably neither economically nor entomologically sound.

If the present small outbreaks continue to increase and the spruce budworm becomes serious enough to kill much ponderosa pine timber (something which as far as we know has never happened before) artificial control may have to be resorted to depending upon the seriousness of the situation. In the meantime studies will be continued on the biology and control of this insect for the purpose of familiarizing ourselves with this apparently new biological strain of the spruce budworm so that we can more intelligently combat it if the need should arise.

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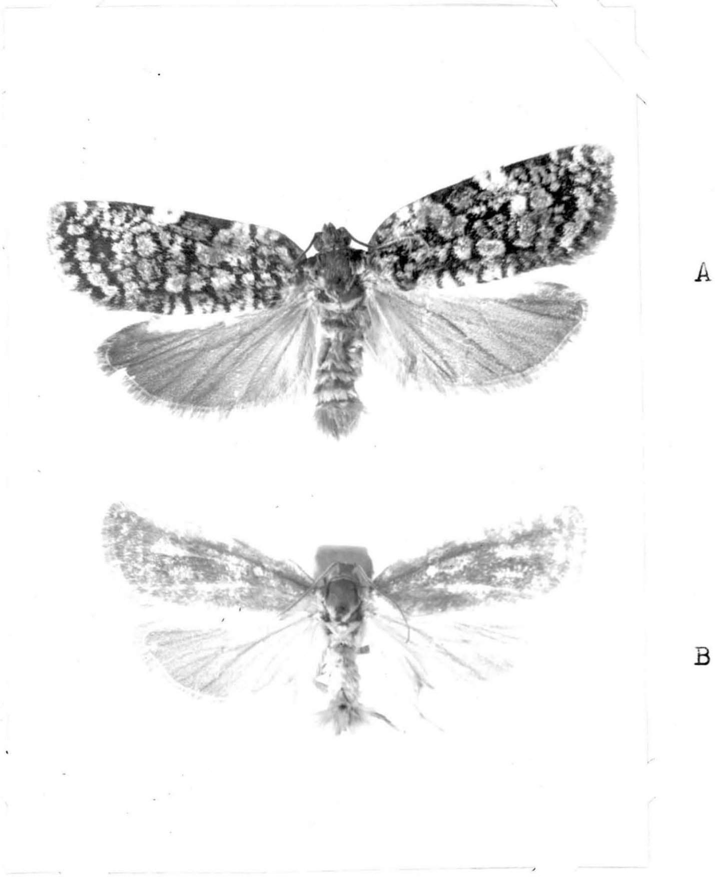


FIG. 1 x3

Top (A)	Adult of spruce budworm reared from Douglas fir -- note larger size and darker color.
Bottom (B)	Adult of spruce budworm reared from ponderosa pine -- note smaller size and lighter color. Photo by N. D. Wygant.

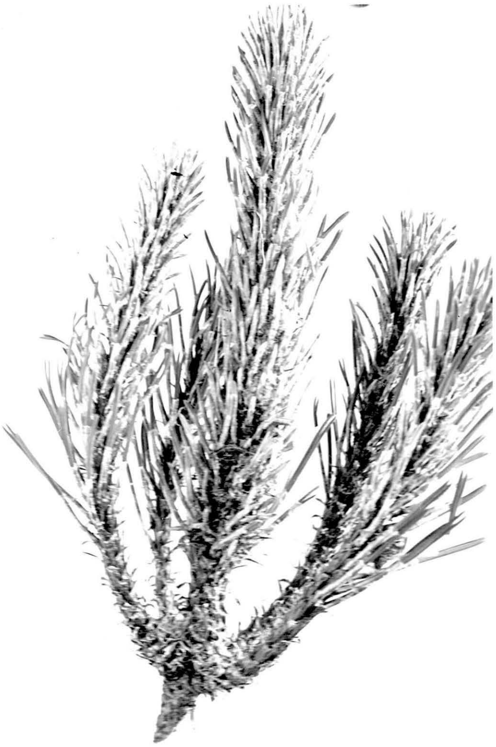
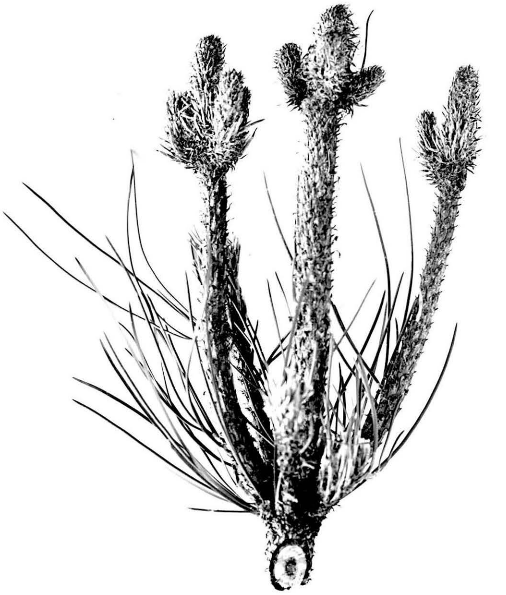


FIG. 2 - Showing new needles on terminal shoots which have been fed upon and killed by larvae of the spruce budworm. Photo by N. D. Wygant.

FIG. 3 - Showing last year's terminal shoots where dead needles have already fallen off and new shoots and new needles killed this year -- in this case two years growth has been killed back by feeding of larvae of the spruce budworm. Photo by N. D. Wygant.



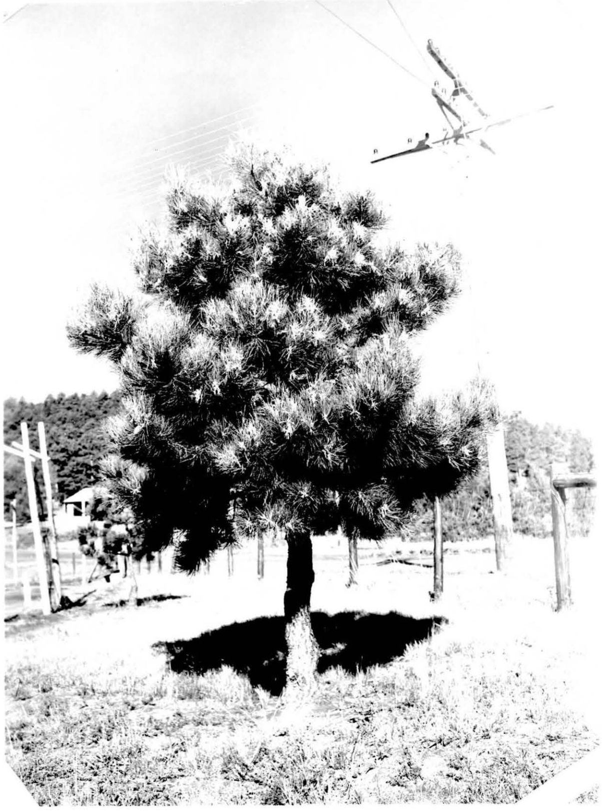


FIG. 4 - Small ponderosa pine showing injury to terminals and laterals resulting from one year's feeding by spruce budworm larvae. Photo by F. R. Lewis.

FIG. 5 - Small ponderosa pine showing injury to terminals and laterals resulting from two years feeding by spruce budworm larvae. Photo by J. A. Beal.